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Xerophytic grasslands at different altitudes in Colorado

FRANCIS RAMALEY

(WITH TWO TEXT FIGURES)

The first comprehensive study of xerophytic grassland in Colorado was reported by Shantz (**16**) for the mesas at Colorado Springs. Later the same author (**17**, **18**) published articles dealing with grasslands of the plains. Important work in the Pikes Peak region has been done by Clements (**1**, **2**) and by Schneider (**15**). During the past few years the present writer (**6**, **7**, **8**, **9**, **10**, **11**, **12**) has published a number of papers dealing with dry grassland of the montane zone at Tolland, Colorado. In a contribution devoted chiefly to successions from marsh vegetation Robbins (**14**) also has given some points on dry grassland at Tolland. A rather brief but very clear and definite account by Vestal (**20**) of foothill grasslands, chiefly near Boulder, is included in a survey by him of the various associations of the foothill zone. An earlier paper by the same author (**19**) characterized the grasslands of the plains in the same locality. Fuller (**3**) has recently made a comparison of the dry grassland at Tolland with black soil prairie in Illinois.

Up to the present time there is no printed comparison of xerophytic grasslands at different altitudes in Colorado. Since these communities occur in large or small stretches all the way from the plains to alpine heights it is evident that very decided ecological and floristic differences must exist. These differences it is the aim of the present paper to report. Observations have been made on some of the areas for ten seasons. Certain localities have, however, been visited only a few times. During the prog-

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ress of the work a large collection has been accumulated which is kept as a special "dry grassland herbarium." Air temperature records have been kept for the growing season at Tolland (8,889 ft.) and these have been compared with reports from the government stations at Boulder (5,340 ft.) and at Corona (11,660 ft.). Soil temperatures have been carefully studied at Boulder and at Tolland, while occasional records have been made in the higher altitudes. The present work does not in any sense cover the whole

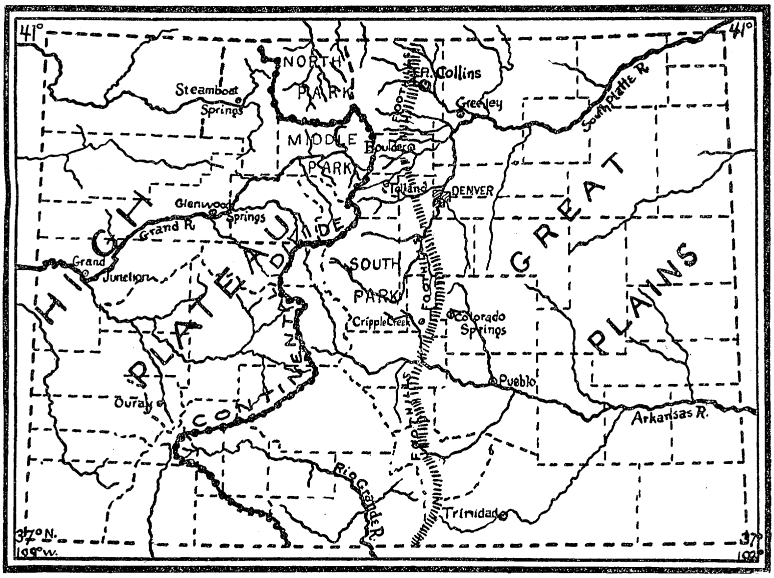

FIG. 1. Map of Colorado showing general geographic features. The Continental Divide extends in a zig-zag course north and south. The foothills at the mountain front are indicated by the series of horizontal lines. Boulder and Tolland are to the northwest of Denver.

of Colorado (FIG. 1) but merely the area tributary to the University at Boulder and the Mountain Laboratory at Tolland. Field work has been done chiefly in a rectangle about 40 miles east and west and 30 miles north and south with altitudes from 5,000 to 14,000 feet above sea level (FIG. 2).

In the following synopsis of xerophytic grasslands, descriptions are omitted because these are available in the writings of Shantz, Vestal, Pound and Clements (5), and the writer. Nichols's (4) exposition of ecological concepts has been followed in choosing names for the different communities. The nomenclature of species is that of Rydberg (13).

SYNOPSIS OF XEROPHYTIC GRASSLANDS IN NORTHERN COLORADO[1]

A. Associations of mixed character belonging to the plains region; not clearly dominated by grasses or sedges:

1. *Gutierrezia-Artemisia* Association.
2. Plains Ruderal Association.
3. *Chrysothamnus* Association.
4. *Artemisia filifolia* Consociation (of the Sand Hills Mixed Association).

B. Associations dominated by sedges; mountain communities not represented on the plains (Ramaley, **11**):

5. *Carex stenophylla* Grassland Association; foothills and montane.
6. *Carex Rossii* Grassland Association; montane and subalpine.
7. *Carex siccata* Grassland Association; montane and subalpine.
8. *Carex elynoides* Grassland Association; subalpine and alpine.

C. Associations of the Mixed Dry Grassland Type:

9. Inceptive Dry Grassland Association of the Foothill Zone (the Foothills Primitive Grassland of Vestal, **20**).
10. Derivative Dry Grassland Association of the Foothill Zone (the Foothills Mixed Grassland of Vestal, **20**).
11. Inceptive Dry Grassland Association of the Montane Zone.
12. Derivative Dry Grassland Association of the Montane Zone.

D. Associations dominated by one or a few species of grasses:

13. Short Grass Association; plains and mountain front; dominated by *Bouteloua* and *Bulbilis*.
14. Wheat Grass Association, mountain front chiefly; dominated by *Agropyron Smithii*.
15. *Andropogon* Bunch Grass Association; plains and mountain front.
16. Porcupine Grass Association; plains and foothills, occasionally montane; dominated by *Stipa*.
17. Sand Hills Mixed Association; plains; dominated by *Calamovilfa* and *Andropogon*.

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[1] It is often difficult to decide just what communities should be included as "grassland." The writer omits lichen and mat associations, since they have almost no grasses or grass-like plants. Communities in which shrubs dominate are excluded; these are best known as "scrub." The Prairie Grass Association (of Vestal) is not included, as it is mesophytic.

18. *Festuca* Bunch Grass Association; montane; dominated by tall cespitose species of *Festuca*.
19. *Muhlenbergia-Danthonia* Consociation (of the Derivative Dry Grassland Association of the Montane Zone).

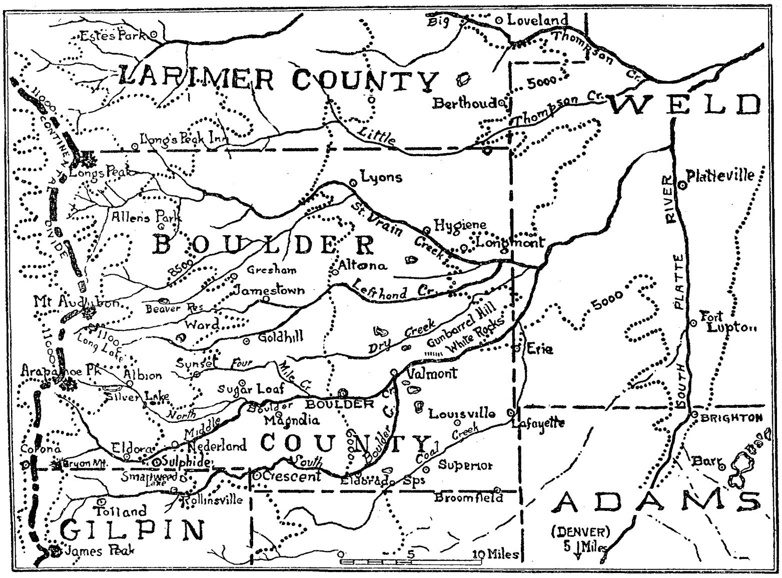

FIG. 2. Map of that part of Colorado readily studied botanically from the University of Colorado at Boulder and from the Mountain Laboratory at Tolland. Contour lines are shown for 5,000 ft., 6,000 ft., 8,500 ft., and 11,000 ft. The mountain front is at about 6,000 ft.

THE MIXED DRY GRASSLAND TYPE

The term "Mixed Dry Grassland," as used by the writer, includes all mountain grasslands of mixed character, growing generally in coarse-grained soil. In the preceding synopsis the communities numbered from 8 to 12 inclusive belong here and also Nos. 1 and 19. Early stages of the Short Grass Association, No. 13, are also of the Mixed Dry Grassland type. The Porcupine Grass Association, No. 16, when it occurs in montane situations may resemble ordinary montane dry grassland, and the *Festuca* Bunch Grass Association, No. 18, is, in places, not so very different. Indeed, any of the grassland associations of the mountains may belong to this general type.

While there is no difficulty in recognizing inceptive and derivative stages of the various dry grasslands the species concerned are much the same. Thus, in the montane area, practically all the species present in the early stages persist throughout; the relative proportions change, however, and more species enter the association as the soil becomes finer grained and as humus accumulates.

Occurrence of these grasslands is wide spread. In the lower part of the foothill region typical vegetation is a coniferous savanna. In the interspaces between trees there is dry grassland. Many intervales, locally known as "parks," are almost entirely without trees. In both foothill and montane areas many stream terraces, alluvial fans, and south-facing hill slopes support dry grassland. In the subalpine zone conditions for forest development are more favorable, and grassland is likely to be confined to burned areas or to wind-swept south exposures.

ENVIRONMENTAL INFLUENCES

The stations where most of the collections were made, with their altitudes, are as follows:

Boulder, 5,340 ft.; mountain front, mesa area.
Crescent, 7,457 ft.; lower foothills.
Rollinsville, 8,367 ft.; upper foothills.
Sulphide, 8,508 ft.; upper foothills.
Smartweed Lake, 8,420 ft.; upper foothills.
Tolland, 8,889 ft.; montane.
Bryan Mountain, 11,000 ft.; subalpine.

Boulder, Crescent, Sulphide and Bryan Mountain are in Boulder County; Rollinsville, Smartweed Lake and Tolland are in Gilpin County (see FIG. 2). Many other stations through both of these counties have been visited.

The soil of all the dry grasslands is disintegrated rock, rather coarse grained, often with pebbles and boulders. It readily permits penetration of rain water but it dries quickly. As shown in a previous paper (10) the water content is low, averaging about 7 per cent, but the wilting coefficient is correspondingly low, about 5; figures being for 3 dm. depth. The soils warm up quickly through direct insolation and show a higher temperature than the air. Floristic differences in the dry grasslands do not depend on soil quality for this is much the same in all, but rather on air temperature (TABLE I), soil temperature (TABLE II), and pre-

TABLE I

MEAN TEMPERATURES IN DEGREES FAHRENHEIT. THOSE AT TOLLAND AND BRYAN MOUNTAIN ARE ESTIMATED, EXCEPT FOR JULY AND AUGUST AT TOLLAND

	Boulder 5,340 ft.	Tolland 8,889 ft.	Bryan Mt. 11,000 ft.
May	56	42	35
June	65	51	44
July	70	57	50
August	70	55	48
September	64	46	39

TABLE II

SOIL TEMPERATURES IN DEGREES FAHRENHEIT OF DRY GRASSLAND AT THREE TYPICAL ALTITUDES; NUMEROUS OBSERVATIONS AT 3 DM. DEPTH

	Boulder 5,340 ft.	Tolland 8,889 ft.	Bryan Mt. 11,000 ft.
May	55		
June	64	54	
July	72	64	58
August	70	62	56
September	64	58	52

Note.—Since readings of soil temperature were taken in the daytime they are somewhat above the true average. Data for Bryan Mountain are rather fragmentary and figures may have to be revised later. Probably the May soil temperature at Bryan Mountain is very low, close to freezing in the early part of the month.

cipitation. The mean annual rainfall at Boulder is 18 inches, at Tolland probably 28 inches, and at Bryan Mountain it can safely be estimated at 38 inches. April is the wettest month at all the stations. At the higher altitudes the greater rainfall and cooler temperature make the grasslands more mesophytic than those of plains and foothills.

SYSTEMATIC LIST OF SPECIES

A list of the species characteristic of xerophytic grasslands at various elevations is given below. Only spermatophytes and pteridophytes are recorded; lower plants, aside from parasitic fungi, are almost entirely unrepresented in dry grassland. It is of importance to note that in montane and subalpine situations, due to the more congenial climatic features mentioned above, a number of species, which in the lowlands are confined to moister soil, may be regular components of dry grassland. This distinction is brought out in the list: the letter *x* signifies that the species is present in dry grassland at that altitude; the letter *o* means that the species is found in moister places rather than in dry grassland at the altitude indicated. The letter *s* means that the species occurs at the altitude named, but only in special situations (where warm or protected) and is not a true component of dry grassland.

	Sub-alpine	Mon-tane	Upper foothill	Lower foothill	Moun-tain front
Selaginellaceae					
Selaginella densa	x	x	x	x	x
Poaceae					
Agropyron biflorum	–	x	x	–	–
" *molle*	–	–	x	x	x
" *pseudorepens*	–	x	x	o	o
" *Richardsoni*	–	x	x	x	x
" *Scribneri*	x	–	–	–	–
" *Smithii*	–	s	x	x	x
" *spicatum*	–	–	x	x	x
" *tenerum*	–	x	x	o	o
Andropogon Hallii	–	–	–	–	x
" *provincialis*	–	–	–	–	x
Aristida longiseta	–	–	–	x	x
Avena Hookeri	–	x	–	–	–
" *Mortoniana*	x	–	–	–	–
Blepharoneuron tricholepis	–	x	x	–	–
Bouteloua curtipendula	–	–	–	x	x
" *gracilis*	–	–	x	x	x
" *hirsuta*	–	–	x	x	x
Bromus brizaeformis (introduced)	–	–	–	–	x
" *Pumpellianus*	–	x	x	–	–
Bulbilis dactyloides	–	–	–	–	x
Calamagrostis purpurascens	x	x	x	–	–
Danthonia intermedia	x	x	–	–	–
" *Parryi*	–	x	x	–	–
Elymus triticoides	–	–	–	x	x
Eriocoma hymenoides	–	–	–	x	x
Festuca brachyphylla	x	–	–	–	–
" *ingrata*	–	x	x	–	–
" *minutiflora*	x	x	–	–	–
" *octoflora*	–	–	–	–	x
" *rubra*	–	x	x	–	–
" *saximontana*	x	x	x	–	x
Hesperochloa Kingii	–	s	x	x	x
Hordeum jubatum	–	x	x	o	o
" *nodosum*	–	–	x	x	x
Koeleria gracilis	–	x	x	x	x
Muhlenbergia gracilis	–	x	x	x	x
" *gracillima*	–	–	–	x	x
" *Richardsonis*	–	x	x	x	x
" *subalpina*	–	x	x	–	–
Pleuraphis mutica	–	–	–	–	x
Poa arctica	x	x	–	–	–
" *compressa*	–	x	x	x	x
" *confusa*	x	–	–	–	–
" *crocata*	x	x	x	x	–
" *epilis*	x	x	–	–	–
" *Fendleriana*	–	–	–	x	x
" *interior*	–	x	x	o	o
" *longipedunculata*	–	x	x	x	x
" *paddensis*	x	x	–	–	–
" *Pattersoni*	x	x	–	–	–
" *pratensis*	–	x	x	o	o
" *rupicola*	x	x	–	–	–
" *subaristata*	x	x	x	x	x

	Sub-alpine	Mon-tane	Upper foothill	Lower foothill	Moun-tain front
Poaceae—*continued*					
Schedonnardus paniculatus	–	–	–	*x*	*x*
Schizachyrium scoparium	–	–	–	*x*	*x*
Sitanion elymoides	–	*x*	*x*	*x*	*x*
Sorghastrum nutans	–	–	–	–	*x*
Sporobolus asperifolius	–	–	–	–	*x*
" *heterolepis*	–	–	–	–	*x*
Stipa comata	–	*x*	*x*	*x*	*x*
" *minor*	–	*x*	*x*	–	–
" *Nelsonii*	–	*x*	*x*	*x*	–
" *Tweedyi*	–	–	*x*	*x*	*x*
" *viridula*	–	*x*	*x*	*x*	*x*
Trisetum majus	–	*x*	*x*	–	–
" *subspicatum*	*x*	*o*	–	–	–
Cyperaceae					
Carex elynoides	*x*	*x*	–	–	–
" *heliophila*	–	*x*	*x*	*x*	*x*
" *obtusata*	–	*x*	*x*	–	–
" *oreocharis*	–	*x*	*x*	*x*	o
" *Rossii*	*x*	*x*	–	–	–
" *siccata*	*x*	*x*	–	–	–
" *stenophylla*	–	*x*	*x*	*x*	*x*
" *xerantica*	–	*x*	*x*	*x*	*x*
Melanthaceae					
Anticlea elegans	*x*	*o*	*o*	–	–
Toxicoscordion gramineum	–	–	–	*x*	*x*
Juncaceae					
Juncoides spicatum	*x*	–	–	–	–
Juncus ater	–	*x*	*x*	o	o
" *interior*	-	–	–	*x*	*x*
Alliaceae					
Allium recurvatum	–	*x*	*x*	*x*	*x*
" *textile*	–	–	–	*x*	*x*
Liliaceae					
Leucocrinum montanum	–	–	–	*x*	*x*
Lloydia serotina	*x*	–	–	–	–
Dracaenaceae					
Yucca glauca	–	–	–	*x*	*x*
Calochortaceae					
Calochortus Gunnisonii	–	*x*	*x*	o	o
Polygonaceae					
Eriogonum alatum	–	–	*x*	*x*	*x*
" *effusum*	–	–	–	–	*x*
" *flavum*	–	–	*x*	*x*	*x*
" *Jamesii*	–	–	–	*x*	*x*
" *umbellatum*	–	*x*	*x*	*x*	*x*
Polygonum Engelmannii	–	*x*	*x*	*x*	*x*
" *sawatchense*	–	–	*x*	*x*	*x*
Chenopodiaceae					
Chenopodium desiccatum	*s*	–	*x*	*x*	*x*
Nyctaginaceae					
Allionia linearis	–	–	–	*x*	*x*
" *pilosa*	–	–	–	*x*	*x*

	Sub-alpine	Montane	Upper foothill	Lower foothill	Mountain front
Corrigiolaceae					
Paronychia Jamesii	–	–	–	*x*	*x*
Alsinaceae					
Alsinopsis obtusiloba	*x*	*x*	–	–	–
Arenaria Fendleri	*x*	*x*	*x*	*x*	–
Cerastium Beeringianum	*x*	–	–	–	–
" *brachypodum*	–	–	–	*x*	*x*
" *campestre*	–	–	*x*	*x*	*x*
" *strictum*	–	*x*	*x*	–	–
Caryophyllaceae					
Silene acaulis	*x*	–	–	–	–
" *Hallii*	–	*x*	*x*	–	–
Ranunculaceae					
Delphinium Penardii	–	–	–	–	*x*
" *virescens*	–	–	–	–	*x*
Pulsatilla ludoviciana	*x*	*o*	*o*	*o*	*o*
Papaveraceae					
Argemone intermedia	–	–	–	*s*	*x*
Brassicaceae					
Cheirinia aspera	–	–	–	*x*	*x*
" *asperrima*	–	–	–	*x*	*x*
" *oblanceolata*	*x*	*x*	*x*	*x*	–
" *Wheeleri*	–	*x*	*x*	*x*	–
Draba coloradensis	–	–	–	*x*	*x*
Lepidium densiflorum	–	–	*x*	*x*	*x*
Lesquerella montana	–	–	*x*	*x*	*x*
Physaria floribunda	–	–	*x*	*x*	*x*
Thlaspi coloradense	*x*	*x*	*x*	*x*	*x*
" *purpurascens*	*x*	*x*	–	–	–
Crassulaceae					
Sedum stenopetalum	*x*	*x*	*x*	*x*	*x*
Saxifragaceae					
Micranthes rhomboidea	*x*	*x*	*x*	*o*	*o*
Rosaceae					
Drymocallis glandulosa	–	*x*	*x*	*x*	*x*
Potentilla concinna	–	*x*	*x*	–	–
" *effusa*	–	*x*	*x*	*x*	*x*
" *Hippiana*	–	*x*	*x*	*x*	*x*
" *strigosa*	–	*x*	*x*	*x*	*x*
Fabaceae					
Aragallus albiflorus	–	–	*x*	*x*	*x*
" *deflexus*	–	*x*	*x*	–	–
" *Lambertii*	–	*x*	*x*	*x*	*x*
" *Richardsonii*	–	*x*	*x*	–	–
Astragalus sulphurescens	–	*x*	*x*	–	–
Geoprumnon succulentum	–	–	–	*x*	*x*
Homalobus flexuosus	–	*x*	*x*	*x*	*x*
Orophaca tridactylica	–	–	–	*x*	*x*
Petalostemon oligophyllus	–	–	–	–	*x*
" *purpureus*	–	–	–	–	*x*
Psoralea argophylla	–	–	–	–	*x*
Psoralea tenuiflora	–	–	–	*x*	*x*

	Sub-alpine	Mon-tane	Upper foothill	Lower foothill	Moun-tain front
Fabaceae—*continued*					
Tium Drummondii	–	–	–	*x*	*x*
Xylophacos Parryi	–	*x*	*x*	–	–
“ *Purshii*	–	–	–	*x*	*x*
“ *Shortianus*	–	–	*x*	*x*	*x*
Geraniaceae					
Geranium Fremontii	–	*s*	*x*	*x*	*x*
“ *Parryi*	–	–	*x*	*x*	*x*
Linaceae					
Linum Lewisii	–	*x*	*x*	*x*	*x*
Euphorbiaceae					
Tithymalus robustus	–	*s*	*x*	*x*	*x*
Malvaceae					
Sphaeralcea coccinea	–	–	–	*x*	*x*
Violaceae					
Viola Nuttallii	–	–	–	*x*	*x*
Cactaceae					
Coryphantha missouriensis	–	–	*x*	*x*	*x*
“ *radiosa*	–	–	*x*	*x*	*x*
Opuntia fragilis	–	–	–	*x*	*x*
“ *polyacantha*	–	–	–	*x*	*x*
Onagraceae					
Gaura coccinea	–	–	–	*x*	*x*
“ *glabra*	–	–	–	*x*	*x*
Meriolix serrulata	–	–	–	*x*	*x*
Ammiaceae					
Aletes acaulis	–	–	–	*x*	*x*
Cogswellia macrocarpa	–	–	–	*x*	*x*
“ *orientalis*	–	–	–	*x*	*x*
Harbouria trachypleura	–	–	*x*	*x*	*x*
Musineon divaricatum	–	–	–	*x*	*x*
“ *pedunculatum*	–	–	–	*x*	–
Oreoxis alpina	*x*	–	–	–	–
Pseudocymopterus tenuifolius	–	*x*	*x*	–	–
Primulaceae					
Androsace diffusa	–	–	*x*	*x*	–
“ *occidentalis*	–	–	–	*x*	*x*
“ *subumbellata*	*x*	*x*	–	–	–
Gentianaceae					
Dasystephana Bigelovii	–	–	*x*	*x*	–
Tessaranthium stenopetalum	–	*x*	*x*	*x*	*o*
Asclepiadaceae					
Acerates angustifolia	–	–	–	–	*x*
“ *viridiflora*	–	–	–	–	*x*
Asclepias pumila	–	–	–	–	*x*
Polemoniaceae					
Collomia linearis	–	–	*x*	*x*	*o*
Gilia scariosa	–	–	*x*	*x*	–
“ *spicata*	–	–	*x*	*x*	*x*
Phlox multiflora	–	–	–	*x*	–
Polemonium confertum	*x*	–	–	–	–

	Sub-alpine	Mon-tane	Upper foothill	Lower foothill	Moun-tain front
Hydrophyllaceae					
Phacelia heterophylla	–	*x*	*x*	*x*	*x*
" *sericea*	*x*	*o*	–	–	–
Boraginaceae					
Mertensia Bakeri	–	*x*	–	–	–
" *cana*	*x*	–	–	–	–
" *lanceolata*	–	–	*x*	*x*	*x*
" *lateriflora*	–	*x*	*x*	–	–
" *lineariloba*	–	–	*x*	–	–
" *Parryi*	*x*	–	–	–	–
Oreocarya virgata	–	*s*	*s*	*x*	*x*
Onosmodium occidentale	–	–	–	–	*x*
Verbenaceae					
Verbena bracteosa	–	–	–	–	*x*
Lamiaceae					
Hedeoma hispida	–	–	–	–	*x*
Monarda pectinata	–	–	–	–	*x*
Scrophulariaceae					
Castilleja occidentalis	*x*	–	–	–	–
" *sessiliflora*	–	–	–	–	*x*
Orthocarpus luteus	–	*x*	*x*	–	–
Pentstemon gracilis	–	–	–	*x*	*x*
Plantaginaceae					
Plantago Purshii	–	–	*x*	*x*	*x*
Rubiaceae					
Galium boreale	–	*x*	*x*	*o*	*o*
Santalaceae					
Comandra pallida	–	*x*	*x*	*x*	*x*
Campanulaceae					
Campanula petiolata	*x*	*x*	*x*	*o*	*o*
Ambrosiaceae					
Ambrosia psilostachya	–	–	*s*	*s*	*x*
Carduaceae					
Achillea lanulosa	*x*	*x*	*x*	*o*	*o*
Antennaria anaphaloides	*x*	*x*	*x*	–	–
" *aprica*	*x*	*x*	*x*	*x*	*x*
" *arida*	–	*x*	*x*	*x*	–
" *campestris*	–	–	–	–	*x*
" *microphylla*	–	*x*	*x*	*x*	*x*
Artemisia aromatica	–	*x*	*x*	*x*	*x*
" *Brittonii*	–	–	*x*	*x*	*x*
" *Forwoodii*	–	*x*	*x*	*x*	*x*
" *frigida*	–	*x*	*x*	*x*	*x*
" *gnaphaloides*	–	*x*	*x*	*x*	*x*
" *Pattersoni*	*x*	–	–	–	–
Aster crassulus	–	–	–	–	*x*
" *Porteri*	–	–	*s*	*x*	*x*
*Chrysopsis asprella**	*x*	*x*	*x*	*x*	*x*
" *foliosa*	–	*x*	*x*	*x*	*x*

* The species of *Chrysopsis* are difficult of separation and it is possible that what the writer has separated as *C. asprella* and *C. hispida* should be combined, also that those listed as *C. foliosa* and *C. villosa* are a single species.

	Sub-alpine	Mon-tane	Upper foothill	Lower foothill	Moun-tain front
Carduaceae—*continued*					
Chrysopsis fulcrata	–	–	*x*	*x*	*x*
" *hispida*	–	–	–	*x*	*x*
" *villosa*	–	*x*	*x*	*x*	*x*
Cirsium undulatum	–	–	–	*x*	*x*
Coreopsis tinctoria	–	–	–	–	*x*
Erigeron canus	–	–	–	–	*x*
" *compositus*	*x*	*x*	*x*	–	–
" *divergens*	–	*s*	*x*	*x*	*x*
" *flagellaris*	–	*x*	*x*	*x*	*x*
Gaillardia aristata	–	*x*	*x*	*o*	*o*
Grindelia erecta	–	*x*	*x*	–	–
" *perennis*	–	–	*x*	–	–
" *squarrosa*	–	–	*x*	*x*	*x*
" *subalpina*	–	*x*	*x*	–	–
Gutierrezia Sarothrae	–	–	–	*s*	*x*
Helianthus petiolaris	–	–	–	*x*	*x*
Hymenopappus filifolius	–	–	–	*x*	*x*
Kuhnia glutinosa	–	–	–	–	*x*
Laciniaria punctata	–	–	–	*x*	*x*
Machaeranthera aspera	–	–	–	*x*	*x*
" *varians*	–	*x*	*x*	–	–
" *viscosa*	–	*x*	*x*	–	–
Ratibida columnifera	–	–	–	–	*x*
Senecio oblanceolatus	–	–	–	*x*	*x*
" *perplexus*	–	*x*	*x*	*o*	*o*
" *plattensis*	–	–	–	–	*x*
" *spartioides*	–	–	–	*x*	*x*
" *werneriaefolius*	*x*	*o*	*o*	–	–
Sideranthus spinulosus	–	–	–	–	*x*
Solidago concinna	–	*x*	*x*	–	–
" *decumbens*	*x*	*x*	–	–	–
" *missouriensis*	–	–	*x*	*x*	*x*
" *nana*	–	–	–	*x*	*x*
" *oreophila*	–	*x*	*o*	–	–
Tetraneuris acaulis	–	–	–	*x*	*x*
" *lanigera*	*x*	–	–	–	–
Tonestus pygmaeus	*x*	–	–	–	–
Townsendia exscapa	–	–	–	*x*	*x*
" *grandiflora*	–	–	*x*	*x*	*x*
Cichoriaceae					
Agoseris glauca	–	*x*	*x*	*x*	*x*
" *purpurea*	–	–	*x*	*x*	*o*
Lygodesmia juncea	–	–	–	–	*x*

FLORISTIC DIFFERENCES OF DRY GRASSLANDS AT DIFFERENT ALTITUDES

The foregoing systematic list gives in brief form the chief facts of altitudinal distribution of the various species in the dry grasslands. At the mountain front, i. e., on the mesas and mesa terraces, there are 160 species. In the lower foothills this number is reduced to 139, in the higher foothills to 130, in the montane area to 107, and in the subalpine area to 50. It will be seen that there is a reduction in species roughly corresponding to increase of altitude. But the change from the montane dry grassland (at Tolland) to the subalpine dry grassland (at Bryan Mountain) is very abrupt.

It is sometimes difficult to decide whether a given species is to be included as properly belonging to a certain grassland. The attempt has been to exclude stragglers and accidental members, in other words to keep the lists reasonably small.

While the systematic list tells what particular species are found at the various stations it gives little idea of the true appearance of each grassland area. At the mountain front, as already noted, there is a great variety of plants. The average height of the vegetation is taller than elsewhere; many of the grasses and other plants are 3–6 dm. tall, and some are taller. Certain species are conspicuous which either do not occur at all higher up or else are infrequent, as, for example, *Agropyron spicatum*, the Andropogons, *Bromus brizaeformis; Yucca glauca*, the Delphiniums, the Petalostemons, *Tium Drummondii*, the various Cactaceae, the Gauras, *Helianthus petiolaris*, *Laciniaria punctata*, and *Ratibida columnifera*.

At Tolland the number of species is still large but a certain few are especially abundant and dominate wide areas, as, for example, the following: *Mertensia Bakeri*, which flowers in May; *Aragallus Lambertii*, which flowers in early July; *Sedum stenopetalum*, in mid-July; *Campanula petiolata* and *Orthocarpus luteus*, in August. The average height of vegetation in midsummer is 2–3 dm. Grasses and sedges are abundant, especially where the soil has considerable humus. Here the dry grassland becomes what the writer calls the *Muhlenbergia-Danthonia* Consociation (of the Derivative Dry Grassland Association of the Montane Zone.)

The dry grassland at Bryan Mountain (*Carex elynoides* Association) has a rather striking appearance because of the tufted masses of the dominant plant. This is, however, of low growth and the association does not look at all like the bunch grass association of the plains. Conditions are somewhat mesophytic on account of low temperature and frequent showers, so that many of the plants recorded as belonging to the dry grassland would also be included in a list of mesophytes. One-third of the species are grasses.

The systematic list includes a total of 256 species in 131 genera and 35 families. The families best represented with the number of genera and species in each are shown below:

Poaceae	25	66	Rosaceae	2	6
Cyperaceae	1	8	Fabaceae	9	16
Polygonaceae	2	7	Ammiaceae	6	8
Alsinaceae	3	6	Boraginaceae	3	8
Brassicaceae	6	10	Carduaceae	23	55

Only 5 species range the whole distance from mountain front to subalpine zone. Of the 50 species at Bryan Mountain 29 extend down to Tolland and only 5 to the mountain front at Boulder. Of the 160 species at Boulder 40 range up to Tolland and 5 continue to Bryan Mountain. Floristically, then, the dry grasslands at Boulder and at Bryan Mountain are almost totally different, while a very considerable similarity exists between those of Boulder and Tolland and of Tolland and Bryan Mountain.

Summary

The foregoing paper is based upon a study of grasslands in northern Colorado from the plains to the subalpine zone. A list is presented of all recognized xerophytic grassland communities in northern Colorado. From this list the author selects for comparison those of the "mixed dry grassland type." Environmental influences, the soil, temperature and rainfall are considered; the very low air and soil temperatures of the subalpine region being noted. To show floristic changes with altitude a systematic list of dry grassland plants is printed and the altitudinal distribution of each species indicated. At the mountain front there are 160 species in the dry grassland, while the numbers at other stations are as follows: lower foothills 139, upper foothills 130, montane area 107, subalpine area 50. Of the last named nearly one-half are strictly high-altitude forms which do not extend down even to the montane zone. It is pointed out that a number of species belonging to moister situations in the lowlands are able to enter dry grasslands of higher altitudes because of lower temperature and greater rainfall there. A brief statement is made of differences in the grasslands not at once apparent from the systematic list. Floristically the dry grasslands of the mountain front and of the subalpine zone are almost totally different, but considerable similarily exists between those of the mountain front and of the montane zone.

UNIVERSITY OF COLORADO,
BOULDER, COLORADO.

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